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WET-STRENGTH DEVELOPMENT WITH DIALDEHYDE STARCH

SUMMARY

Exploratory experiments have been completed using dialdehyde starches as wet-strength agents for Weyerhaeuser bleached sulfite pulp. Methods used to retain the starches and improve their effectiveness were: Precipitation with rosin and alum, combination with 11% alum, combination with a coupling agent of the dicyandiamide-formaldehyde type, combination with cationic starch, and combinations with protein (casein and glue).

Optimum wet-strength properties were obtained through the addition of 5% of a 1:1 blend of dialdehyde starch and Peter Cooper glue. In this case, wet tensile approached 30% of dry tensile. Without the glue, the dialdehyde starches provided rather minor improvements in wet strength under the experimental conditions employed. Glue alone yielded 10-14% wet strength.

INTRODUCTION

This is report No. 35 on Institute Project 849. The purpose of this work was to find a suitable mechanism for improving the wet-strength properties developed through the use of dialdehyde starch in papermaking furnishes.

EXPERIMENTAL

Three hundred and sixty grams (ovendry basis) of Weyerhaeuser bleached sulfite pulp were soaked in 6 liters of tap water for a minimum of 4 hours. The Valley beater was filled to the 17-liter mark with tap water. The pulp was added and slushed for 5 minutes with the balance weight on the bedplate arm. The pulp was then beaten at a consistency of 1.55% to a S.R.-freeness of 700-720 cc.

The materials used in the handsheets were: USDA 96% oxidized dialdehyde cornstarch, Sumstar 190, Sumstar-S, and periodate oxidized high amylose starch, Peter Cooper No. 220 TG Ground Paper Glue, casein, Cato-8, and a coupling agent (a special retention aid for dialdehyde starch). Sumstar-190, Sumstar-S, and the coupling agent are made by Miles Laboratories. Cato-8 is a commercial cationic starch marketed by National Starch Products.

SERIES I

Preparation of Starch Dispersion

Ten grams of 96% oxidized dialdehyde cornstarch were heated in 200 g. of deionized water over steam in the presence of 15% sodium bisulfite based on ovendry starch. After heating for a total of 45 min. at 95°C. the starch was cooled to room temperature.

Preparation of Glue Dispersion

Ten grams (ovendry basis) of Peter Cooper No. 220 TG Ground Paper Glue was soaked in 200 g. of deionized water for 2 hours at room temperature. The slurry was then heated on a steam cone to 55°C. and cooked for 15 min. at this temperature with moderate agitation. The glue was then cooled to room temperature.

Where used, a 50:50 blend of starch and glue was made by mixing the two precooled components.

Handsheet Preparation

Eight sets of handsheets (2.5 g. each) were made on the Noble & Wood sheet mold. When used, starch was stirred in for 20 min., glue for 15 min., and the starch-glue mixture for 15 min. When rosin and alum were used, the pH was held at 4.5-5.0 throughout the sheet-making process. All rosin and alum additions were stirred in for 5 min. All sheets were pressed for 5 min. at 50 p.s.i. and dried for 7 min. at 3.5 lb. steam on the steam drum.

Code No.	Description
849-1005-147-1	Blank control
" " " 2	5% starch
" " " 3	5% glue
" " " 4	5% mix (starch-glue)
" " " 5	Rosin-alum control, 2% rosin, 4% alum
" " " 6	5% starch, 2% rosin, 4% alum
" " " 7	5% glue, 2% rosin, 4% alum
" " " 8	5% mix, 2% rosin, 4% alum

Handsheets were tested for basis weight, dry tensile, and wet tensile. Results are listed in Table I.

TABLE I

WET-STRENGTH PROPERTIES OF HANDSHEETS
CONTAINING DIALDEHYDE STARCH

Code No.	Description	Basis Wt., lb. 25x40/500	Dry Schopper Tensile	Wet Tensile, 10 hr. soak	Wet Tensile, 30 min. soak
849-1005-147-1	Blank control	47.4	20.7	0.82	--
849-1005-147-2	5% starch	46.8	22.2	0.76	--
849-1005-147-3	5% glue	44.4	20.5	0.83	--
849-1005-147-4	5% 50:50 glue & starch	46.8	21.8	0.89	--
849-1005-147-5	2% rosin, 4% alum	43.9	19.9	1.11	1.6
849-1005-147-6	2% rosin, 4% alum, 5% starch	45.0	22.5	1.34	3.9
849-1005-147-7	2% rosin, 4% alum, 5% glue	46.3	29.4	2.23	3.2
849-1005-147-8	5% 50:50 starch & glue, 2% rosin, 4% alum	43.9	24.9	2.77	5.6

SERIES 2

Preparations for Cook 1

Distilled water was heated to 87-91°C. and pH adjusted to 5.0-5.5. Enough Sumstar-190 was added to make a 3% dispersion. To this was added 15% sodium bisulfite based on the Sumstar-190. The mixture was cooked at 90-95°C. for 40 minutes, cooled rapidly to room temperature, diluted to 1.0% solids and pH adjusted to 4.5-5.5.

Preparations for Cook 2

Same as Cook 1 except that Sumstar-S was substituted for Sumstar-190.

Preparations for Cook 3

Same as Cook 1 except that periodate-oxidized high amylose starch was substituted for Sumstar-190.

Preparations for Cook 4

A 5% dispersion of Cato-8 was prepared by booking the slurry at 95°C. for 30 minutes. The pH was adjusted to 4.5-5.5.

Preparations for Cook 5

Fifteen grams of Peter Cooper No. 220 TG Ground Paper Glue were soaked in 285 ml. of deionized water (5% dispersion) for 2 hours. The slurry was cooked in the steam cone for 15 minutes at 55°C. and cooled to room temperature.

Handsheet Preparations

Thirteen sets of handsheets (1.2 g. each) were made on the British sheet mold. Where used, a special coupling agent (dicyandiamide-formaldehyde type) was stirred into the pulp furnish at 1.5% consistency for 30 minutes. Sumstar-190, Sumstar-S, and periodate-oxidized high-amylose starch were stirred in for 10 minutes. Cato-8, Peter Cooper glue, and combinations of glue and starch were allowed to contact the pulp for 15 minutes; the 11% alum addition for 5 minutes, and all rosin-alum additions for 5 minutes. Where rosin-alum was used, the pH was maintained at 4.5-5.0. All sheets were pressed at 50 p.s.i. for 5 minutes, and dried on the steam drum at 3.5 lb. steam for 7 minutes. The following descriptions pertain.

Code	Description
849-1962-20-12	0.5% of coupling agent, 1.0% of Cook 1
849-1962-21-13	0.5% of coupling agent, 1.0% of Cook 2
849-1962-21-14	0.5% of coupling agent, 1.0% of Cook 3
849-1962-21-15	0.5% of coupling agent
849-1962-21-16	11.0% of alum, 5.0% of Sumstar-S
849-1962-21-17	11.0% of alum, 5.0% of Sumstar-190
849-1962-22-18	11.0% alum control
849-1962-22-19	2.5% of Cato-8, 2.5% of Sumstar-S added separately
849-1962-22-20	2.5% of Cato-8, 2.5% of periodate-oxidized high-amylose starch
849-1962-22-21	2.5% of Cato
849-1962-23-22	5.0% of 50:50 blend glue:Sumstar-S 2% of rosin, 4% of alum
849-1962-23-23	5% of 50:50 blend glue:periodate-oxidized high-amylose starch, 2% of rosin, 4% of alum
849-1962-24-24	2.5% of glue, 2% of rosin, 4% of alum

Samples were tested for basis weight, caliper, apparent density, Mullen bursting strength, M.I.T. fold, wet tensile, and dry tensile. Results are presented in Table II.

TABLE II

RESULTS ON HANDSHEETS CONTAINING DIALDEHYDE STARCH

[illegible]	...s Wt., ...b. ...0/500	Caliper, mils	Apparent Density	Mullen Burst. Pts.	Mullen Burst. Pts./100 lb.	M.I.T. Fold	Schopper Tensile, lb./in.	Wet Tensile, lb./in., 30 min. soak, pH 5.5-6.0	Wet Tensile, lb./in., 30 min. soak, pH 10.0	Wet Tensile, %
[illegible]	...4.3	4.0	11.1	33.8	76	196	18.8	1.1	0.8	--
[illegible]	...4.1	4.0	11.0	34.3	78	203	18.7	1.0	0.9	--
[illegible]	...4.4	4.0	11.1	33.2	75	236	19.7	1.0	0.9	--
[illegible]	...4.4	4.0	11.1	35.2	79	209	19.2	0.9	0.8	--
[illegible]	...0.9	3.8	10.8	31.2	76	117	17.1	0.9	0.7	--
[illegible]	...3.0	4.0	10.8	33.3	77	206	19.8	1.0	0.8	--
[illegible]	...5.7	4.1	11.1	34.0	74	145	21.2	0.9	0.8	--
[illegible]	...5.1	4.0	11.3	45.4	101	576	24.8	1.4	0.7	--
[illegible]	...5.3	4.0	11.3	46.2	102	465	25.2	1.5	0.7	--
[illegible]	...3.2	4.0	10.8	43.7	101	517	23.4	1.0	0.7	--
[illegible]	...2.4	4.0	10.6	37.8	89	276	22.0	6.3	3.8	28.6
[illegible]	...2.7	4.0	10.7	39.6	93	417	23.2	6.9	4.5	29.7
[illegible]	...3.7	4.0	10.9	39.6	91	434	23.6	3.1	1.3	13.1

SERIES 3

Preparations for Cook 1

The pH of distilled water was adjusted to 5.0-5.5. Sufficient Sumstar-190 was added to make a 3% dispersion. Fifteen per cent of sodium bilsufite was added, based on the weight of Sumstar-190. The mixture was heated to 90-95°C. for 40 minutes, cooled rapidly to room temperature, diluted to 1.0% solids and pH adjusted to 4.5-5.0.

Preparations for Cook 2

Same as Cook 1 except that Sumstar-S was substituted for Sumstar-190.

Preparations for Cook 3

A 3% dispersion of Peter Cooper glue was prepared by soaking in deionized water for hours at room temperature. The slurry was then heated to 55°C. and cooked at this temperature for 15 minutes with moderate agitation, followed by cooling to room temperature.

Preparations for Cook 4

Fifty grams of casein were added to 250 grams of water and heated to 50-55°C. Three millileters of ammonia were added and stirred at 50-55°C. for 45 minutes. The dispersion was diluted to 5% solids with warm water and cooled to room temperature.

Handsheet Preparations

Twelve sets of handsheets (1.2 g. each) were made in the British sheet mold. The coupling agent (dicyandiamide-formaldehyde type) was stirred in for 30 minutes, and Sumstar 190 for ten minutes. Casein, glue, a casein-

Sumstar-S blend, and a glue-Sumstar-S blend were stirred for 15 minutes; the formalin and rosin-alum addition was stirred for 5 minutes. Where rosin-alum was used, the pH was maintained at 4.5-5.0 throughout the entire sheetmaking process. The forming consistency in the sheet mold for Sets 3 and 4 (see description) was 0.2%. In Sets 4 to 12, the pH of the furnish at 1.5% consistency was adjusted to 5.0-6.0. The following descriptions pertain:

Code	Description
849-1962-27-1	Blank control
849-1962-27-2	Rosin-alum control (2% of rosin, 4% of alum)
849-1962-27-3	Blank control at 0.2% forming consistency
849-1962-27-4	0.5% of coupling agent, 1.0% of Sumstar-190, 0.2% forming consistency
849-1962-27-5	5% of casein, 2% of rosin, 4% of alum
849-1962-28-6	5% of 1:1 ratio of casein:Sumstar-S, 2% of rosin, 4% of alum
849-1962-28-7	3% of 1:1 ratio of casein:Sumstar-S, 2% of rosin, 4% of alum
849-1962-28-8	1% of 1:1 ratio of glue:Sumstar-S, 2% of rosin, 4% of alum
849-1962-28-9	3% of 1:1 ratio of glue:Sumstar-S, 2% of rosin, 4% of alum
849-1962-29-10	1.0% of glue, 2% or rosin, 4% of alum
849-1962-29-11	3% of glue, 2% of rosin, 4% of alum
849-1962-29-12	5% of glue, 2% of rosin, 4% of alum, 5% of formalin

Sheets were tested for basis weight, dry tensile, wet tensile. The results are listed in Table III.

TABLE III

WET-STRENGTH PROPERTIES OF HANDSHEETS CONTAINING DIALDEHYDE STARCH

Code No.	Description	Basis Wt., lb., 25 x 40/500	Dry Tensile, lb./in.	Wet Tensile, lb./in., 30 min. soak, pH 5.5-6.0	Wet Tensile, lb./in., 30 min. soak, pH 10.0	% Wet Strength Based on pH 5.6-6.0 Reading
849-1962-27-1	Blank	44.2	19.7	0.9	0.8	4.6
849-1962-27-2	Rosin and alum	45.0	17.9	1.1	1.0	6.1
849-1962-27-3	Blank at 0.2% consistency	46.4	16.4	0.7	0.6	4.3
849-1962-27-4	0.5% coupling agent, 1.0% Sumstar-190(formed, 0.2% consistency)	43.1	16.2	2.0	0.7	12.3
849-1962-27-5	5% casein, rosin and alum	46.8	23.2	2.2	2.1	9.5
849-1962-27-6	5% 1:1 casein:Sumstar-S, rosin and alum	46.7	21.2	1.8	1.1	8.5
849-1962-27-7	3% 1:1 casein:Sumstar-S, rosin and alum	45.7	21.5	1.5	1.0	7.0
849-1962-27-8	1% 1:1 glue:Sumstar-S, rosin and alum	46.0	20.1	1.5	1.2	7.5
849-1962-27-9	3% 1:1 glue:Sumstar-S, rosin and alum	45.0	20.3	3.1	1.9	15.3
849-1962-27-10	1% glue, rosin and alum	46.5	21.3	0.9	0.8	4.2
849-1962-27-11	3% glue, rosin and alum	49.5	23.3	3.3	2.3	14.2
849-1962-27-12	5% glue, rosin and alum, 5% formaldehyde	45.1	22.8	2.7	2.0	11.8

DISCUSSION OF RESULTS

It is evident from the results of these exploratory studies that the most satisfactory mechanism for use with dialdehyde starch is the glue-starch blend in combination with rosin and alum. It is further evident that 5% of the blend is required to produce wet-strength values in the range of 25-30% of dry. Lower additions of the glue-starch combination did not show substantial advantages over the glue controls although it is expected that the relatively high wet-strength value exhibited by the 3% glue control (Set No. 849-1962-27-11) was aided by high basis weight.

Other retention mechanisms such as the use of the dicyandiamide coupling agent as supported by Miles Laboratories, the use of 11% of alum as described by Hofreiter (1), and combinations of cationic starch and dialdehyde starch as suggested by Hamerstrand (2) did not provide substantial wet strength.

LITERATURE CITED

1. Hofreiter, B., Hamerstrand, G., Mehltretter, C., Schulze, W., and Ernst, A., Tappi 43, No. 7:639-643(July, 1960).

2. Hamerstrand, G. E., Hofreiter, B. T., Mehltretter, C. L., Schulze, W. E., and Kay, Daniel J., Tappi 44, No. 6:430-433(June, 1961).

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EVALUATION OF ESPINA CORONA GUM AS A BEATER ADDITIVE

INTRODUCTION

This is Project Report 34 on Project 849, an Institute of Paper Chemistry project for testing of new materials, for the evaluating of Espina Corona gum as a beater additive.

In recent years, Locust Bean gum had been used in increasing amount as a beater additive in paper industry for providing the physical strength of the treated paper. It was decided to add 0.5%, 1%, and 5% of Espina Corona gum based on the pulp and compare the results with the Locust Bean gum at the same additions.

EXPERIMENTAL PROCEDURE

PREPARATION OF 0.05% SOLIDS GUM SOLUTIONS

The 0.5% solids solutions of Locust Bean gum and Espina Corona gum were cooked separately as follows:

Sprinkle powdered gum into cold water with constant stirring. Heat with steam to 95°C. and hold there for 10 minutes. Weigh and adjust solids content with water.

BEATER RUN AND HANDSHEET PREPARATION

After soaking 360 g. of oven-dried Weyerhaeuser pulp overnight in six liters of water, the pulp was added to the Valley Beater, diluted to the 23-liter mark and slushed five minutes with the balance weight added. The pH in the beater was adjusted to 7 with 2% H_2SO_4. The 5500 g. weight was added, the pulp was then beaten to a Schopper-Riegler freeness of 740 cc. The beater consistency was around 1.5%. A calculated amount of this beaten pulp was taken for each furnish. The gum solution prepared as above was added to the furnish and stirred for 15 minutes. After this time the consistency was diluted to 0.5% by the addition of tap water. The sheets were made in the Rapid Kothen sheet mold. All sheets were pressed at 50 lb. pressure for five minutes and were dried three minutes at 3.5 lb. steam. Eight sheets were made for each set. Basis weight, caliper, bursting strength, tear, tensile, and M.I.T. folding endurance measurements were determined for each set. The data are shown in Table I.

TABLE I

COMPARISON OF 0.5%, 1%, and 5% ADDITIONS OF ESPINA CORONA GUM AND LOCUST BEAN GUM AS BEATER ADDITIVES

Additive		Basis Wt., lb. 25x40/500	Thickness, mils	Mullen Bursting Strength, points	Mullen Bursting Strength, pt. per 100 lb.	Elmendorf Tear, g./sheet	Tear Factor	M.I.T. Fold	Schopper Tensile, lb./inch
Control	Max.		4.2	45.0		53		624	25.6
	Min.		4.0	38.0		43		256	20.5
	Av.	48.7	4.1	41.6	85	48	0.99	399	23.8
0.5% Espina Corona gum	Max.		4.1	50.0		45		755	30.8
	Min.		4.0	39.0		42		435	22.3
	Av.	48.3	4.1	46.2	96	44	0.91	553	25.4
1% Espina Corona gum	Max.		4.0	51.5		45		1017	32.0
	Min.		4.0	40.5		40		290	20.0
	Av.	48.2	4.0	48.0	100	41	0.85	590	26.8
5% Espina Corona gum	Max.		4.3	57.5		45		1398	33.0
	Min.		4.2	46.5		38		508	24.5
	Av.	50.1	4.2	52.6	105	42	0.84	948	27.5
0.5% Locust Bean gum	Max.		4.2	53.0		43		622	30.8
	Min.		4.1	39.0		38		169	19.6
	Av.	49.2	4.1	47.2	96	41	0.83	425	24.1
1% Locust Bean gum	Max.		4.3	55.0		48		919	32.3
	Min.		4.0	44.0		38		251	21.8
	Av.	48.6	4.1	49.4	102	41	0.84	714	27.4
5% Locust Bean gum	Max.		4.8	58.0		48		1597	35.9
	Min.		4.1	45.5		38		867	28.6
	Av.	50.8	4.5	52.9	104	43	0.85	1150	33.0

Note: The samples were conditioned and tested at 50% R.H. and 73°F.

RESULTS AND OBSERVATIONS

The Espina Corona gum appears to have a noticeable amount of dirt and impurity, but there was no difficulty in dispersing it into the solution.

At 0.5% addition, both Espina Corona gum and Locust Bean gum increased the bursting strength from 85 to 96 pt. per 100 lb. At the 1% additions, the Espina Corona gum increased from 85 pt. to 100 pt. per 100 lb.; the Locust Bean gum increased to 102 pt. per 100 lb. In the 5% additions, both again increased the bursting strength to about 105 pt. per 100 lb.

There was a trend to decrease the tear factor on addition of both Espina Corona gum and the Locust Bean gum, but the results were not significant.

Both Espina Corona gum and Locust Bean gum increased the M.I.T. folding endurance according to the amount added to the stock. At the 0.5% additions, Espina Corona gum increased the strength about 30% while the Locust Bean gum increased the strength only 6.5%. At the 1% addition, Espina Corona gum increased 47.9% and Locust Bean gum increased the strength 79%. At the 5% addition, Espina Corona gum increased the strength 138% while the Locust Bean gum showed a strength increase of 188%. The results showed that at 0.5% addition, the Espina Corona gum was more effective then the Locust Bean gum at the same level. However, the higher percentages of additions, 1% and 5%, showed the Locust Bean gum to be more effective than the Espina Corona gum.

Both gums increased tensile strength proportionally to the amount that was present in the paper. For Espina Corona gum, at the 0.5%, 1%, and 5% additions, it increased the tensile strength 6.7, 12.6 and 15.5%, respectively. For Locust Bean gum there was no significant change in strength at 0.5% additions, while at 1 and 5%

additions, it increased the strength 15.1% and 38.2%, respectively. The results indicated that at the higher levels of addition, 1 and 5%, Locust Bean gum was again more effective than Espina Corona gum at the same level of additions.

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A PRELIMINARY EVALUATION OF TAMARIND SEED MEAL AND ACCOSTRENGTH RESIN 2386 AS BEATER ADHESIVES

SUMMARY

Samples of tamarind seed meal obtained from the Murbas Trading Company and of Accostrength Resin 2386 provided by American Cyanamid Company were evaluated as beater adhesives by preparing handsheets from Weyerhaeuser bleached sulfite pulp containing 0.0, 0.5, 1.0, and 2.0% of these products based on the fiber weight. Studies were made with and without the presence of rosin. The prepared handsheets were tested for basis weight, caliper, Mullen burst, Schopper tensile, Elmendorf tear, M.I.T. fold and TAPPI size.

The results of the forementioned tests indicate that both tamarind seed meal and Accostrength Resin significantly improve strength properties with the resin being the better of the two.

Comparison of the results at the 1% addition level in the absence of rosin shows that tamarind seed resulted in a 30% improvement in bursting strength, a 32% improvement in tensile, and a 240% improvement in fold. Accostrength Resin, under the same conditions, resulted in a 46% improvement in burst, a 31% improvement in tensile, and a 700% improvement in fold. The addition of 2% of tamarind seed meal, in the absence of rosin, did not offer an appreciable advantage over the 1% addition level. The 2% addition of Accostrength, however, resulted in significantly superior strength values over the lower level. As might be expected, the tear factor generally decreased as the other physical strengths increased. The results of the

TAPPI size tests indicate that neither the tamarind seed nor the Accostrength Resin, in themselves, are effective sizing agents for paper.

The tamarind seed meal was somewhat less effective in the presence of rosin than without the size. The effectiveness of the Accostrength Resin, on the other hand, was comparable in the presence of rosin insofar as the percentage of improvement is concerned. At the 1% addition level tamarind seed resulted in a 25% improvement in burst, an 11% increase in tensile, and a 156% improvement in fold. Accostrength, under similar conditions, resulted in a 56% improvement in burst, a 35% increase in tensile, and a 960% improvement in fold. The TAPPI size results, with rosin present, indicate that both the tamarind seed and Accostrength Resin improve sizing slightly with the resin being slightly superior in this respect.

INTRODUCTION

The present report is concerned with a preliminary evaluation of tamarind seed meal and a synthetic resin, Accostrength Resin 2386, as beater adhesives.

Information supplied by the Murbas Trading Company indicates that tamarind seed meal has been found satisfactory as a beater adhesive and a sizing agent for paper in India.

In literature provided by the American Cyanamid Company, Accostrength Resin 2386 is claimed to improve tensile, burst, and folding strengths, increase interfiber bonding and pick resistance. Incorporation of 0.73% of Accostrength Resin into a sulfite pulp supposedly resulted in a 62% improvement in burst and a 35% improvement in tensile. Addition of Accostrength to pulp is also claimed to result in; (a) little apparent change in bulk or porosity, (b) improved filler retention, (c) improved sizing from rosin size, (d) faster drainage, (e) wet web strength, and (f) lower steam consumption in the drier section.

EXPERIMENTAL AND DISCUSSION

BEATER RUN

Three-hundred and ninety grams of Weyerhaeuser bleached sulfite pulp were soaked overnight in six liters of water. The Valley beater was filled with 17 liters of tap water the temperature of which was adjusted to 25°C. The soaked pulp was added to the beater and the pH of the slurry was adjusted to 7.0 with 2% sulfuric acid. After slushing for 5 minutes the pulp was beaten for 32 minutes under a bedplate load of 5500 grams to an S.R. freeness of 700 cc. The pulp consistency was measured at 1.58%.

BEATER ADHESIVE PREPARATIONS

Tamarind gum was prepared as a 1% dispersion by boiling the seed meal in distilled water for 15 minutes with constant agitation. After cooling the slurry 3% of boric acid was added with stirring.

The Accostrength Resin was prepared as a 1% aqueous solution at room temperature.

HANDSHEET PREPARATION

Twenty grams of D.D. pulp or 1270 g. aliquots of beaten pulp were used for each furnish. The tamarind gum and Accostrength Resin solutions were added to the pulp at 0.0, 0.5, 1.0, and 2.0% based on the fiber weight. After stirring 1/2 hour, the pH of the furnish was reduced to 4.5-5.0 with alum. In those cases where rosin was employed, 2% of the size was stirred into the pulp prior to the addition of alum. The furnish was then diluted to 0.5% consistency with tap water. Forty-five pound per ream handsheets

(25 x 40/500) were prepared in the usual manner on the Valley sheetmold with the pH maintained at 4.5-5.0 by the addition of 2% sulfuric acid. The sheets were pressed five minutes at 50 lbs. pressure and dried 7 minutes sheetside up on the steam drier at 3.5# pressure. Eight handsheets were prepared from each furnish and were tested for basis weight, caliper, Mullen burst, Elmendorf tear, Schopper tensile, M.I.T. fold and TAPPI size.

The physical test results on the unsized handsheets are presented in Table I.

Table II lists the results on the rosin-sized sheets.

Although it is not legitimate to compare the absolute strength values obtained in the current evaluation with results obtained under similar conditions in previous studies it is, nevertheless, interesting to compare the percentage of strength improvement over control sheets at a common level of addition. In previous experiments described in Project Report 32 it was shown that 1% of cooked locust bean gum (Lycoid Royal) improved bursting strength by 34% and tensile by 10% when added to Weyerhaeuser bleached sulfite pulp. One percent of cooked guar gum (Lycoid CPMC) under similar conditions, resulted in improvements of 33 and 13% in burst and tensile respectively. The 1% addition of a pregelatinized potato starch (Speedjel P O) resulted in 48 and 28% improvements in burst and tensile respectively. On the basis of these values, tamarind seed compares favorably with the locust bean and guar gums and Accostrength Resin is as good as, or better than, the potato starch.

PHYSICAL TEST RESULTS ON UNSIZED HANDSHEETS CONTAINING TAMARIND SEED MEAL OR ACCOSTRENGTH RESIN 2386

Code No.	Identification	Basis wt. lbs. 25 x 40/500	Caliper, in.	Mullen Burst points	Mullen Burst pts./100 lb.	Elmendorf tear g./sheet	Tear factor	Schopper tensile lb./inch	M.I.T. fold	TAPPI size sec.
849-H-C-O	Blank Control	44.3	0.0043	23.2	52.4	46	1.04	14.6	33	INST.
849-H-Tam.-0.5	0.5% of Tamarind	47.4	0.0048	29.0	61.2	50	1.05	17.4	62	INST.
849-H-Tam.-1.0	1.0% of Tamarind	46.9	0.0048	32.0	68.2	48	1.02	19.3	113	INST.
849-H-Tam.-2.0	2.0% of Tamarind	46.8	0.0047	32.8	70.1	44	0.94	19.1	139	INST.
849-H-ACCO-0.5	0.5% of Accostrength	47.3	0.0047	32.2	68.1	44	0.93	17.5	100	INST.
849-H-ACCO-1.0	1.0% of Accostrength	47.4	0.0047	36.2	76.4	43	0.91	19.2	267	INST.
849-H-ACCO-2.0	2.0% of Accostrength	49.6	0.0049	43.6	87.9	41	0.83	22.9	616	INST.

PHYSICAL TEST RESULTS ON ROSIN SIZED HANDSHEETS CONTAINING TAMARIND SEED MEAL OR ACCOSTRENGTH RESIN 2386

Code No.	Identification	Basis wt. lbs. 25 x 40/500	Caliper, in.	Mullen Burst points	Mullen Burst pts./100 lb.	Elmendorf tear g./sheet	Tear factor	Schopper tensile lb./inch	M.I.T. fold	TAPPI size sec.
849-H-C-0'	Rosin Control	46.8	0.0046	22.6	48.3	53	1.13	16.0	23	24
849-H-Tam.-0.5'	0.5% of Tamarind + 2% of Rosin	46.7	0.0047	24.6	52.7	48	1.03	16.5	31	29
849-H-Tam.-1.0'	1.0% of Tamarind + 2% of Rosin	47.8	0.0048	28.9	60.5	48	1.00	17.8	59	31
849-H-Tam.-2.0'	2.0% of Tamarind + 2.0% of Rosin	46.8	0.0045	30.4	65.0	45	0.96	19.0	97	29
849-H-ACCO-0.5'	0.5% of Accostrength + 2% of Rosin	46.2	0.0047	28.6	61.9	46	1.00	18.9	84	33
849-H-ACCO-1.0'	1.0% of Accostrength + 2% of Rosin	46.9	0.0046	35.4	75.5	42	0.90	21.6	243	33
849-H-ACCO-2.0'	2.0% of Accostrength + 2% of Rosin	46.1	0.0045	37.2	80.7	37	0.80	22.4	425	33

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Gerald R. Hoffman

A PRELIMINARY EVALUATION OF LYCOIDS ROYAL,
OPMC, and OPMT AND SPEEDJEL
AS BEATER ADHESIVES

SUMMARY

In a comparison of the physical strength properties, handsheets were made from Weyerhaeuser bleached sulfite with the following materials added to the furnish based on the weight of the fiber:0.0, 1.0, 2.0 and 3.0% of cooked Lycoids, Royal, OPMT, and OPMC; 1.0, 2.0, and 3.0% uncooked Lycoids, OPMT and OPMC; 1.0, 3.0 and 5.0% uncooked Speedjel PO. The handsheets were tested for basis weight, caliper, Mullen burst, Elmendorf tear, Schopper tensile, and M.I.T. fold.

In general the physical strength properties increased with increased additions of the beater adhesives with the exception of the tear factor which normally decreases when the other physical strength properties increase. No significant difference existed between the physical strength properties of the cooked and uncooked Lycoid OPMC but a definite improvement existed in sheets made with cooked OPMT over those made with uncooked OPMT.

It was noted that sheets made with the cooked Lycoids at corresponding addition levels exhibited approximately the same physical strength properties.

In comparing the physical strength properties of handsheets made with cooked Lycoids, Lycoid Royal, at the 3.0% addition level, exhibited the highest bursting strength, 90 points per 100 pounds. Lycoids OPMT and Royal, at the 3.0% addition level, had the highest tensile strength, 21.5 pounds per inch, while OPMT, at the same level, had the highest folding strength, 336.

Correspondingly, for the three uncooked materials, Speedjel PO, at the 1 and 3% levels of addition, was superior to the others with respect to bursting, tensile, and folding strengths. In fact, Speedjel PO appears to be a more effective beater adhesive than cooked Lycoid Royal.

The pH's of 3% slurries of the Lycoids was noted. Lycoid OPMC was acidic while OPMT and Royal were basic.

INTRODUCTION

The purpose of the present evaluation is to make a comparison of the relative physical strength developing capacities of the Stein-Hall Lycoid gums and Speedjel PO when used as beater adhesives.

Lycoids OPMC and OPMT are guar gums, OPMT being the technical grade. Lycoid Royal is a locust bean gum. Speedjel PO is an imported Dutch pregelatinized potato starch.

EXPERIMENTAL

Three hundred and ninety grams of Weyerhaeuser bleached sulfite were soaked in six liters of tap water for two hours. The Valley beater was filled to the 17 liter mark with tap water adjusted to 25°C. and a pH of 7.0 with 2% sulphuric acid. The soaked pulp was added to the beater and slushed for five minutes with the balance weight on the bed plate. The pulp was beaten for 26 minutes to a Schopper-Riegler freeness of 700 cc. The beater consistency was measured at 1.52%.

Forty-five pound per ream handsheets were made on the Valley sheet mold. The sheets contained 0.0, 1.0, 2.0 and 3.0% cooked Lycoid Royal, 1.0, 2.0 and 3.0% cooked Lycoid OPMT, 1.0, 2.0, and 3.0% cooked Lycoid OPMC, 1.0, 2.0 and 3.0% uncooked Lycoid OPMC, 1.0, 2.0 and 3.0% uncooked Lycoid OPMT and 1.0, 3.0 and 5.0% uncooked Speedjel PO. The percentages are based on the weight of the fiber. Each set contained eight handsheets.

Twenty gram aliquots (O.D. Basis) or 1316 ml. of beaten pulp were placed in a bucket. The uncooked adhesives were placed directly in the pulp and allowed to stir in the pulp 30 minutes prior to addition of sufficient alum to lower the pH to 4.5-5.0. The alum was allowed to stir in the pulp for five minutes before dilution to 0.5% consistency.

The cooked dispersions of Lycoids Royal, OPMC and OPMT were prepared at the 0.5% level by stirring and heating the materials at 95°C. for 15 minutes on the steam bath. The cooked materials were allowed to stir in the pulp for 15 minutes prior to reduction of the pH to 4.5-5.0 with alum.

Handsheets were made in the usual manner with the pH adjusted to 4.5-5.0 in the sheet mold with 2% sulphuric acid. The sheets were pressed at 50 lb. pressure for 5 minutes and dried sheet side up on the steam drier for 7 minutes at 3.5 pounds of steam.

The pH's of 3% slurries of the Lycoids were noted. OPMC had a pH of 5.6, OPMT 8.4 and Royal 8.6.

Specks of undispersed material were apparent on sheets at the 2.0 and 3.0% addition level of uncooked Lycoids OPMC and OPMT and at the 5% addition level of Speedjel.

The forementioned handsheets were submitted for basis weight, caliper, Mullen burst, M.I.T. fold, Schopper tensile and Elmendorf tear.

The following table gives a list of the data.

TABLE I

PHYSICAL TEST DATA FOR HANDSHEETS CONTAINING VARIOUS BEATER ADHESIVES

Beater Adhesives Added to the furnish (Based on Fiber, %)	Basis Weight, lb. 25 x 40/500	Caliper in.	Bursting Strength (Mullen) Points	Bursting Strength (Mullen) Points Per 100 lb.	Elmendorf Tear, g./sheet	Tear Factor	Schopper Tensile, lb./inch	M.I.T. Fold
Blank Control	46.5	.0040	28.5	61	58	1.25	17.5	51
1% Cooked Lycoid Royal	45.7	.0040	37.4	82	46	1.01	19.3	152
2% Cooked Lycoid Royal	45.7	.0038	39.9	87	46	1.01	21.5	194
3% Cooked Lycoid Royal	45.3	.0038	40.6	90	39	0.86	21.1	253
1% Cooked Lycoid OPMC	46.6	.0039	37.8	81	49	1.05	19.8	160
2% Cooked Lycoid OPMC	45.6	.0038	38.6	85	44	0.96	20.8	184
3% Cooked Lycoid OPMC	47.5	.0039	41.7	88	45	0.95	21.2	231
1% Cooked Lycoid OPMT	45.4	.0039	35.7	79	46	1.01	20.0	167
2% Cooked Lycoid OPMT	46.5	.0039	39.8	86	44	0.95	21.5	184
3% Cooked Lycoid OPMT	45.0	.0038	39.2	87	41	0.91	21.0	336
1% Uncooked Lycoid OPMC	46.4	.0038	37.9	82	44	0.95	20.3	150
2% Uncooked Lycoid OPMC	45.8	.0038	38.7	84	44	0.96	20.7	199
3% Uncooked Lycoid OPMC	46.1	.0039	40.4	88	45	0.98	21.1	217
1% Uncooked Lycoid OPMT	45.4	.0040	34.6	76	48	1.06	18.0	96
2% Uncooked Lycoid OPMT	46.9	.0039	36.4	78	47	1.00	20.6	147
3% Uncooked Lycoid OPMT	44.3	.0038	33.9	77	41	0.93	19.1	198
1% Uncooked Speedjel PO	46.2	.0040	41.6	90	45	0.97	22.4	244
3% Uncooked Speedjel PO	46.7	.0040	43.3	93	42	0.90	24.5	301
5% Uncooked Speedjel PO	45.7	.0039	43.8	96	40	0.88	22.8	342

PROJECT REPORT FORM

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A PRELIMINARY EVALUATION OF PARTIALLY HYDROLYZED LARCH ARABOGALACTANS, PAPER BIRCH HEMICELLULOSE AND A CHLORINATED CELLULOSE PRODUCT AS BEATER ADHESIVES

SUMMARY

Four products, prepared in the laboratory, were evaluated as beater adhesives by comparison with a locust bean gum control. These materials* included two larchwood arabogalactans, one partially hydrolyzed with 0.1 N acetic acid, the other partially hydrolyzed with 0.01 N oxalic acid. Also included were a paper birch hemicellulose and a chlorinated cellulose product. These materials were added at 0.0 and 5% (based on the wt. of fiber) to alpha pulp which had been beaten to approximately 750 cc. Schopper-Riegler freeness. The locust bean gum was added at 3% on the fiber weight. Results of the physical tests run on handsheets prepared from the forementioned furnishes indicate that paper birch hemicellulose generally improved strength properties. The 5% addition of this polymer resulted in improvements over the blank in bursting and tensile strengths of 52% and 35%, respectively. Fold, which is normally erratic, improved by a factor of 5-6 while tear decreased from 1.24 to 0.94.

*The arabogalactans and paper birch hemicellulose were supplied by Dr. Wise. The chlorinated cellulose product was obtained from Dr. Tu.

The partially hydrolyzed arabogalactans offered slight improvements in physical strength over the blank control but not a sufficient amount to be considered significant. The chlorinated cellulose product resulted in strength properties almost identical to the blank control.

INTRODUCTION

In line with the work of Thompson, Swanson, and Wise (1) the present report is primarily concerned with the possible use of two partially hydrolyzed arabogalactans and a hardwood hemicellulose as beater adhesives. A fourth material, prepared by treating cellulose with dichloro acetic acid, was also included.

It was previously found (1) that arabogalactans were completely ineffective as beater adhesives probably due to their highly branched nature. It was hoped to sever to some extent this highly branched system by partial hydrolysis and thereby render the arabogalactans more retentive.

It has also been shown (1) that softwood hemicelluloses are superior to hardwood hemicelluloses as beater adhesives. This superiority of the softwoods is attributed to the higher mannan content of these woods. Consequently, the hemicellulose of paper birch would be of interest in being a hardwood. It is also of interest because of its availability. The presently evaluated sample represented approximately 20% of the extractive-free wood. The theoretical yield is approximately 32%.

EXPERIMENTAL PROCEDURE

The arabogalactans considered in the present report were evaluated independently of the hemicellulose and chlorinated cellulose product. The following general procedure was employed in both instances.

Three hundred and ninety grams (air dried basis) of alpha pulp were soaked overnight in six liters of water. The Valley beater was filled to the 17 liter mark with tap water and the soaked pulp was added to yield a total volume of 23 liters. After adjusting the temperature to 25°C. and the pH to 7.0, the pulp was slushed 5 minutes with the balance weight on the bedplate. The pulp was then beaten to approximately 750 cc. S.-R. under a load of 5500 grams. The beater was emptied and the consistency measured.

The first series of handsheets was composed of 4 sets--a blank, two sets with arabogalactans, and one locust bean gum control. The second series of handsheets was comprised of 3 sets--a blank, the hemicellulose, and the chlorinated cellulose product. Each furnish was treated in the following manner: To the pulp at approximately 1.5% consistency was added 5% (on the weight of the fiber) of one of the four products under consideration or 3% of locust bean gum followed by acidification to pH 4.5. The materials studied were added as 1% aqueous dispersions and the locust bean gum as a 0.5% aqueous dispersion. After stirring 1/2 hour the slurry was diluted to 0.5% consistency with the pH maintained at 4.5 to 5.0. One and one-half gram handsheets were then prepared in the usual manner on the Valley sheet mold with the pH again maintained at 4.5 to 5.0. All sheets were pressed five minutes at 50 lb. pressure and dried seven minutes sheetside up on the steam drier at a pressure of 3.5 lb. Each set, composed of 8 sheets each, was submitted for basis wt., bursting strength, folding endurance, tear, and dry tensile strength. The results of these physical tests are presented in Table I.

DISCUSSION OF RESULTS AND FUTURE WORK

As the results indicate, the paper birch hemicellulose shows promise as a beater adhesive. The magnitude of improvement over the controls with this material at the 5% addition level parallels or exceeds the effectiveness of several other softwood hemicelluloses (1) at the same level of addition and locust bean gum at 3% addition. This is somewhat surprising when considering the negligible mannan content found in most hardwood "hemis".

In view of the results obtained it would seem logical to prepare another series of handsheets in which the birch "hemi" would be added at 1, 3 & 5% (based on the weight of the fiber) and comparison would be made with established beater adhesives including several softwood hemicelluloses.

BIBLIOGRAPHY

(1) Thompson, J. O., Swanson, J. W., and Wise, L. E., Tappi 36, no. 12: 534-541 (December, 1953).

jjb/mab

TABLE I

BEATER ADHESIVE EVALUATION DATA

Code No.	Material Added	Basis Weight, lb. 25 X 40/500	Bursting Strength, Mullen Points	Pt./100 lb.	M.I.T. Fold	Elmendorf Tear g./sheet	Tear Factor	Schopper Tensile, lb./inch
849-H-0	Blank Control for the First Series of Sheets	41.3	13.5	33	6	44	1.07	9.9
849-H-AG-AC-5	5% of a Larch Arabogalactan Partially Hydrolyzed with 0.1 N Acetic Acid	43.6	15.5	36	8	45	1.03	11.2
849-H-AG-OX-5	5% of a Larch Arabogalatcan Partially Hydrolyzed with 0.01 N Oxalic Acid	44.0	16.8	38	10	48	1.09	11.7
849-H-LBG-3	3% of Locust Bean Gum	43.5	25.6	59	42	38	0.87	15.9
849-H-0-2	Blank Control for the Second Series of Sheets	43.7	25.6	59	37	54	1.24	14.8
849-H-PBH-5	5% of Paper Birch Hemi-cellulose	43.5	39.0	90	230	41	0.94	20.0
849-H-CPC-5	5% of a Chlorinated Cellulose Product	43.7	26.8	61	37	55	1.26	15.0

Note: The samples were conditioned and tested at 50% R.H., 73°F.

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SUMMARY

The okra samples were extracted for the purpose of determining their deflocculating ability. In general, the fiber formation in the sheets was good, but little different than the control sheets. Slightly better formation was obtained when extracts of three to four-day old pods were used.

The mucilage content was determined colorimetrically with a Coleman Universal spectrophotometer. Anthrone was used to develop the color in the solutions. The three to four-day old pods appeared to contain the largest amounts of mucilage.

INTRODUCTION

Five varieties of okra (Green Velvet, Market, Gold Coast, Emerald, and Dwarf) were received August 15, 1954. Each variety contained samples of pods (3-4, 5-6, and 7-8 days old) and a sample of the roots. The mucilage was to be extracted from each of these samples.

The extractions were then to be added to handsheets in an attempt to determine their usefulness as deflocculating agents.

EXPERIMENTAL PROCEDURE AND DISCUSSION

Extraction of the Mucilage from Okra Samples.

Thirty grams of the sample were weighed out on a trip balance, cut into small pieces, and placed in a Waring Blendor. Three hundred milliliters of distilled water and three milliliters of formaldehyde were mixed together and added to the sample in the blendor. The mixture was then beaten two minutes, poured into a beaker, and allowed to stand for one hour.

After standing the required length of time the liquid was filtered through cloth. Since the filtering process was quite slow it was necessary to force the liquid through the cloth by holding the ends together and squeesing. This first extraction was then weighed and placed in a 500-milliliter ground-glass stoppered bottle.

The solid residue was removed from the cloth and placed in the blendor with 300 milliliters of distilled water and 3 milliliters of formaldehyde. It was beaten thirty seconds, placed in a beaker, and allowed to stand for two hours. The second extraction was again filtered through cloth, squeezed dry, weighed, and placed in a stoppered bottle.

The residue was placed on a watch glass and allowed to dry prior to weighing.

The following table gives the weight in grams of each extraction and the weight of the residue directly following it.

TABLE I

GRAMS OF EXTRACTS AND RESIDUES

Variety and Extract	Three and Four-Day Samples	Residue	Five and Six-Day Samples	Residue	Seven and Eight-Day Samples	Residue	Roots	Residue
Gold Coast								
1st Extract	267.4	0.8	282.5	0.8	287.2	1.1	261.3	10.5
2nd Extract	324.5		288.9		297.0		307.3	
Emerald								
1st Extract	256.1	2.2	279.8	1.5	284.2	1.0	261.1	12.4
2nd Extract	322.2		305.8		314.9		298.5	
Market								
1st Extract	280.0	1.0	272.3	1.8	281.7	1.5	261.6	18.3
2nd Extract	285.3		266.9		254.8		295.0	
Dwarf								
1st Extract	259.1	2.1	275.1	1.1	262.8	2.1	271.6	11.8
2nd Extract	325.3		313.2		310.0		286.9	
Green Velvet								
1st Extract	237.8	3.3	271.6	1.0	270.0	1.2	262.0	12.3
2nd Extract	314.4		286.0		310.0		298.1	

The comparatively heavy residues for the root samples are caused by the fibrous nature of these samples.

PREPARATION OF HANDSHEETS

Ten grams of Manila pulp were weighed out on a trip balance, torn into small pieces, and placed in a Waring Blendor with 500 milliliters of distilled water. The pulp was beaten for two minutes and then diluted to 0.3 per cent consistency by the addition of distilled water.

Five hundred milliliters of pulp were taken for each handsheet, thus giving a 1.5 gram sheet. The pulp was poured back and forth between two beakers--two times into one beaker, three times into the other. Then 7.5 grams, 5 per cent based on the weight of the fiber, of the first okra extraction were added. The mixture was then poured back and forth in the same manner.

The pulp and okra mixture was placed in a Valley sheet mold, which was then filled to the 2,273-milliliter mark. The mixture was stirred by hand, the water was drained out, and the sheet was lifted from the screen on a blotter. The sheets were pressed at 50 pounds pressure and dried at 3.5 pounds steam.

Two sheets were made from each of the first extractions, including the first root extractions. The first and last sheets were control sheets.

The sheets were prepared to determine the deflocculating ability of the okra extracts. The extracts appeared to have little, if any, influence on the formation of the fibers. The fiber formation was fairly good throughout the entire series of sheets.

DETERMINATION OF THE MUCILAGE CONTENT

Rather than weighing out several samples of each okra extract, drying them in an oven, and then reweighing, a colorimetric method of determining solids seemed more advantageous. In an attempt to determine if a straight line function could be obtained, the first extract of the 3-4 day old pods of Gold Coast okra was diluted to various concentrations with distilled water. Five milliliters of the diluted extract were placed in a test tube, ten milliliters of anthrone (one gram anthrone in 500 milliliters of 95 per cent sulfuric acid) were let down the side of the test table, the tube was shaken thirty seconds, and then set aside for ten minutes to insure complete color development.

The solution was then placed in a one-centimeter wide cell and the transmittance was determined with a Coleman Universal spectrophotometer. Distilled water was used as a reference solution and the wavelength was 625 millimicrons.

The following table gives the transmittance for the various concentrations of extract, including a blank solution, containing distilled water and anthrone.

TABLE II

PER CENT TRANSMITTANCE FOR VARIOUS CONCENTRATIONS OF THE FIRST EXTRACT OF 3-4 DAY OLD GOLD COAST OKRA PODS

Concentration,%	Transmittancy, %
2.0	15.0
1.0	41.0
0.5	59.3
0.2	79.0
0.1	84.5
0.0 (blank)	91.1

In order to determine the percentage of mucilage in the reference solution, two samples of the first extract of 3-4 day old Gold Coast okra pods were weighed on an analytical balance, evaporated to dryness in a vacuum oven, and then reweighed. The mucilage content was calculated to be 0.661 per cent for sample 1 and 0.666 per cent for sample 2; the average was then taken as 0.664 per cent.

With the above data a standard curve was drawn on semilogarithmic graph paper.

It was now possible to determine the mucilage content in all the extractions; therefore, 0.70 milliliters of the second extracts of the pods and both the first and second extracts of the roots were diluted to 100 milliliters in a volumetric flask. In the first extracts of the pods, 0.75

milliliters of the okra solutions were diluted to 100 milliliters with distilled water. Ten milliliters of anthrone were added to 5 milliliters of the diluted extract in a test tube, the solution was shaken thirty seconds, and then set aside for ten minutes.

In order to obtain the percentage of mucilage from the concentration of reference solution (column four in the following table) a correction equation was used. For the first extracts of the pods the equation is:

$$\text{Percentage of mucilage} = \frac{A \times 0.00664 \times 100}{0.75}$$

where A = the corresponding concentration of reference solution.

For the second extracts of the pods and the both extracts of the roots the equation becomes:

$$\text{Percentage of mucilage:} \quad \frac{A \times 0.00664 \times 100}{0.70}$$

where A = the corresponding concentration of reference solution.

The following table give the mucilage content in each extract.

TABLE III

MUCILAGE CONTENT

Variety and Extract	Age in Days of Pods	Per Cent Transmittance	Corresponding Concentration of Reference Solution	Percentage of Mucilage
Gold Coast - 1 (Reference)	3-4	--	--	0.664
Gold Coast - 2	3-4	88.2	0.13	0.123
Gold Coast - 1	5-6	57.1	0.57	0.505
Gold Coast - 2	5-6	91.4	0.075	0.071
Gold Coast - 1	7-8	57.5	0.567	0.502
Gold Coast - 2	7-8	90.0	0.105	0.0996
Gold Coast - 1	Roots	58.1	0.683	0.648
Gold Coast - 2	Roots	85.7	0.17	0.161
Emerald - 1	3-4	52.0	0.69	0.611
Emerald - 2	3-4	86.0	0.16	0.152
Emerald - 1	5-6	54.3	0.634	0.561
Emerald - 2	5-6	89.5	0.115	0.109
Emerald - 1	7-8	50.0	0.734	0.650
Emerald - 2	7-8	88.1	0.13	0.123
Emerald - 1	Roots	61.1	0.62	0.588
Emerald - 2	Roots	90.3	0.10	0.095
Market - 1	3-4	54.2	0.634	0.561
Market - 2	3-4	91.1	0.085	0.0806
Market - 1	5-6	62.9	0.45	0.478
Market - 2	5-6	89.0	0.117	0.111
Market - 1	7-8	63.4	0.44	0.390
Market - 2	7-8	91.7	0.075	0.071
Market - 1	Roots	52.3	0.82	0.778
Market - 2	Roots	87.7	0.14	0.133
Dwarf - 1	3-4	49.5	0.75	0.664
Dwarf - 2	3-4	85.5	0.17	0.161
Dwarf - 1	5-6	57.1	0.57	0.505
Dwarf - 2	5-6	89.7	0.114	0.108
Dwarf - 1	7-8	57.5	0.567	0.502
Dwarf - 2	7-8	90.4	0.10	0.095

TABLE III (Cont'd)

MUCILAGE CONTENT

Variety and Extract	Age in Days of Pods	Per Cent Transmittance	Corresponding Concentration of Reference Solution	Percentage of Mucilage
Dwarf - 1	Roots	56.9	0.716	0.679
Dwarf - 2	Roots	88.7	0.12	0.114
Green Velvet - 1	3-4	51.5	0.71	0.629
Green Velvet - 2	3-4	85.7	0.17	0.161
Green Velvet - 1	5-6	56.5	0.583	0.516
Green Velvet - 2	5-6	88.3	0.116	0.110
Green Velvet - 1	7-8	53.3	0.65	0.575
Green Velvet - 2	7-8	89.5	0.115	0.109
Green Velvet - 1	Roots	64.0	0.555	0.526
Green Velvet - 2	Roots	88.5	0.125	0.119

The preceding table gives the data necessary for calculating the percentage of mucilage in each sample, however, we are primarily interested in the total weight of mucilage in the samples.

The following table gives the total weight of mucilage in each sample and the percentage of mucilage, based on the weight of the sample.

TABLE IV

WEIGHT AND PERCENTAGE OF MUCILAGE IN EACH OKRA SAMPLE

Variety and Extract	Age in Days of Pods	Percentage of Mucilage	Weight in Grams of Extracts	Weight in Grams of Mucilage	Grams of Mucilage in First and Second Extracts	Percentage of Mucilage in Each Sample
Gold Coast -1	3-4	0.664	267.4	1.77	2.17	7.23
Gold Coast - 2	3-4	0.123	324.5	0.40		
Gold Coast - 1	5-6	0.505	282.5	1.43	1.64	5.47
Gold Coast - 2	5-6	0.071	288.9	0.21		
Gold Coast - 1	7-8	0.502	287.2	1.44	1.73	5.77
Gold Coast - 2	7-8	0.0996	297.0	0.30		
Gold Coast - 1	Roots	0.648	261.3	1.69	2.18	7.27
Gold Coast - 2	Roots	0.161	307.3	0.49		
Emerald - 1	3-4	0.611	256.1	1.56	2.05	6.83
Emerald - 2	3-4	0.152	322.2	0.49		
Emerald - 1	5-6	0.561	279.8	1.57	1.90	6.33
Emerald - 2	5-6	0.109	305.8	0.33		
Emerald - 1	7-8	0.650	284.2	1.85	2.24	7.47
Emerald - 2	7-8	0.123	314.9	0.39		
Emerald - 1	Roots	0.588	261.1	1.53	1.81	6.03
Emerald - 2	Roots	0.095	298.5	0.28		
Market - 1	3-4	0.561	280.0	1.57	1.80	6.00
Market - 2	3-4	0.0806	285.3	0.23		
Market - 1	5-6	0.478	272.3	1.30	1.60	5.33
Market - 2	5-6	0.111	266.9	0.30		
Market - 1	7-8	0.390	281.7	1.10	1.28	4.27
Market - 2	7-8	0.071	254.8	0.18		
Market - 1	Roots	0.778	261.6	2.04	2.43	8.10
Market - 2	Roots	0.133	295.0	0.39		
Dwarf - 1	3-4	0.664	259.1	1.72	2.24	7.47
Dwarf - 2	3-4	0.161	325.3	0.52		
Dwarf - 1	5-6	0.505	275.1	1.39	1.73	5.77
Dwarf - 2	5-6	0.108	313.2	0.34		
Dwarf - 1	7-8	0.502	262.8	1.32	1.61	5.37
Dwarf - 2	7-8	0.095	310.0	0.29		

TABLE IV (Continued)

WEIGHT AND PERCENTAGE OF MUCILAGE IN EACH OKRA SAMPLE

Variety and Extract	Age in Days of Pods	Percentage of Mucilage	Weight in Grams of Extracts	Weight in Grams of Mucilage	Grams of Mucilage in First and Second Extracts	Percentage of Mucilage in Each Sample
Dwarf - 1	Roots	0.679	271.6	1.83	2.16	7.20
Dwarf - 2	Roots	0.114	286.9	0.33		
Green Velvet-1	3-4	0.629	237.8	1.50	2.01	6.70
Green Velvet-2	3-4	0.161	314.4	0.51		
Green Velvet-1	5-6	0.516	271.6	1.40	1.71	5.70
Green Velvet-2	5-6	0.110	286.0	0.31		
Green Velvet-1	7-8	0.575	270.0	1.55	1.89	6.30
Green Velvet-2	7-8	0.109	310.0	0.34		
Green Velvet-1	Roots	0.526	262.0	1.38	1.73	5.77
Green Velvet-2	Roots	0.119	298.1	0.35		

In the following table the grams of residue are combined with the grams of mucilage to give the total solids in each sample. The percentage of mucilage is then calculated on the basis of the total solids. The table also indicates the apparent viscosity as being high, medium, or low. This viscosity was determined entirely by observation.

TABLE V

PERCENTAGE OF MUCILAGE IN THE TOTAL SOLIDS AND THE VISCOSITY OF THE EXTRACTS

ariety and Extract	Age in Days of Pods	Grams of Mucilage	Grams of Residue	Total Grams of Solids	Percentage of Mucilage in Total Solids	Viscosity
old Coast - 1	3-4	2.17	0.8	2.97	73.1	High
old Coast - 2	3-4					Low
old Coast - 1	5-6	1.64	0.8	2.44	67.2	Medium
old Coast - 2	5-6					Medium
old Coast - 1	7-8	1.73	1.1	2.83	61.1	Low
old Coast - 2	7-8					Low
ld Coast - 1	Roots	2.18	10.5	12.68	17.2	Low
ld Coast - 2	Roots					Low
erald - 1	3-4	2.05	2.2	4.25	48.2	High
erald - 2	3-4					Medium
erald - 1	5-6	1.90	1.50	3.40	55.9	Medium
erald - 2	5-6					Medium
erald - 1	7-8	2.24	1.0	3.24	69.1	Medium
erald - 2	7-8					Medium
rald - 1	Roots	1.81	12.4	14.21	12.7	Low
rald - 2	Roots					Low
ket - 1	3-4	1.80	1.0	2.80	64.3	High
ket - 2	3-4					Low
ket - 1	5-6	1.60	1.80	3.40	47.1	Medium
ket - 2	5-6					Medium
ket - 1	7-8	1.28	1.5	2.78	46.0	Low
ket - 2	7-8					Low
ket - 1	Roots	2.43	18.3	20.73	11.7	Low
ket - 2	Roots					Low
rf - 1	3-4	2.24	2.1	4.34	51.6	High
rf - 2	3-4					Medium
rf - 1	5-6	1.73	1.1	2.83	61.1	High
rf - 2	5-6					Medium
rf - 1	7-8	1.61	2.1	3.71	46.1	Low
rf - 2	7-8					Medium

TABLE V (CONT'D)

PERCENTAGE OF MUCILAGE IN THE TOTAL SOLIDS AND THE VISCOSITY OF THE EXTRACTS

ariety and Extract	Age in Days of Pods	Grams of Mucilage	Grams of Residue	Total Grams of Solids	Percentage of Mucilage in Total Solids	Viscosity
warf - 1	Roots	2.16	11.8	13.96	15.5	Low
warf - 2	Roots					Low
reen Velvet - 1	3-4	2.01	3.3	5.31	39.7	High
reen Velvet - 2	3-4					Medium
reen Velvet - 1	5-6	1.71	1.0	2.71	63.1	Low
reen Velvet - 2	5-6					Low
reen Velvet - 1	7-8	1.89	1.2	3.09	61.2	High
reen Velvet - 2	7-8					Medium
reen Velvet - 1	Roots					Low
reen Velvet - 2	Roots	1.73	12.3	14.03	12.3	Low

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